## INTRODUCTION

In this module you will learn about the potential health effects of ionizing radiation, acute and chronic radiation exposure, and ways that radioactive material can enter the body. You will learn that the potential for you to receive a significant or damaging amount of radiation during an emergency response situation is extremely low.

## PURPOSE

The purpose of this module is to increase your understanding of how ionizing radiation affects the human body. This knowledge will help you, as a responder, function with confidence during incidents that involve radioactive material.

## MODULE OBJECTIVES

Upon completion of this module, you will be able to:

1. Define acute and chronic radiation doses.
2. Identify ways that radioactive material can enter the body.
3. Identify the potential health effects of radiation exposure.

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## RADIATION: Dose and Dose Rate

Radiation dose is the amount of radiation energy deposited in the body. Radiation dose rate is a measure of the rate at which radiation energy is deposited in the body. Radiation dose rate is often measured in terms of exposure per unit time. This is like the speedometer and odometer in your car. The speedometer measures your rate of speed—like dose rate. And, the odometer measures the total distance traveled—like total dose received.

Radiation dose is usually measured in terms of millirem and radiation dose rate is usually measured in terms of millirem per hour. In the United States, the annual average radiation dose per person from all sources is about 360 mrem; however, it isn't uncommon for any of us to receive far more than that in a given year (largely due to medical procedures we may have done). As an example, workers at nuclear facilities are allowed up to 5,000 mrem of radiation exposure each year.

## BIOLOGICAL EFFECTS OF IONIZING RADIATION

Scientists began to collect and analyze information about the biological effects of ionizing radiation shortly after its discovery. We now know more about the biological effects of ionizing radiation than we do about many other environmental hazards.

Information on biological effects generally comes from four groups of people who have been exposed to significant levels of radiation:

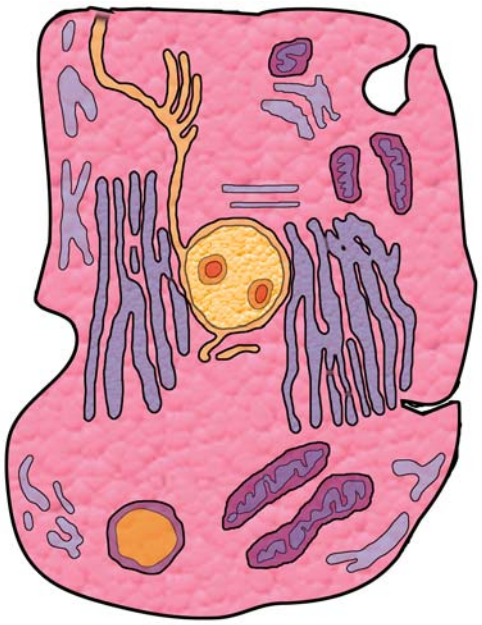
- Early radiation workers who received large doses of radiation before scientists recognized that there were biological effects and consequences. Exposure standards have since been established to protect workers and the public.
- 100,000+ survivors of the atomic blasts in Hiroshima and Nagasaki.

- People who have been involved in radiation accidents at nuclear facilities. There have been incidents involving radiological material, equipment, and processes throughout the world. The Chernobyl accident is one example.
- Cancer patients. This group is the largest. Patients in this group undergo exposure to high levels of ionizing radiation to treat their disease.

Information gained from years of radiation-related research has helped determine more specifically how ionizing radiation can damage the human body, and what levels of exposure cause what kinds of damage.

**How Ionizing Radiation Affects the Body**

Scientists have determined that the effects of ionizing radiation occur at the cellular level. The human body is made up of many organs, and each organ of the body is made up of specialized cells. Ionizing radiation can affect the normal operation of these cells.



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The way radiation causes damage to any material is by ionizing the atoms in that material—changing the atomic structure of the material. When atoms are ionized, the chemical properties of those atoms are altered. This is how radiation can damage a cell; it ionizes the atoms and changes the resulting chemical behavior of the atoms and/or molecules in the cell. If a person receives a sufficiently high dose of radiation and many cells are damaged, there may be noticeable—observable—health effects.

Some human cells are more sensitive to environmental factors than others. These environmental factors include viruses, toxins, and ionizing radiation. Radiation damage to cells depends on how sensitive the cells are to ionizing radiation.

Generally speaking, the most sensitive cells are those that divide rapidly or those that are in the process of dividing. These cells are most vulnerable because it is difficult or impossible for them to repair any damage that may occur during cell division. Examples of highly vulnerable cells include blood-forming cells, the cells that line our intestinal tract, hair follicle cells, and the cells in an embryo or fetus. Cells that divide more slowly and cells that are more specialized (brain and muscle cells) are not as easily damaged by ionizing radiation.

The biological effects of ionizing radiation depend on how much and how fast a radiation dose is received. There are two categories of radiation doses: acute radiation doses and chronic radiation doses.

**Acute Doses**

Exposure to a large dose of radiation received in a short period of time is called an acute dose. The body can't repair or replace cells fast enough after a large acute dose of radiation, so physical effects may be seen. Some possible health effects from acute doses of radiation include reduced blood count, hair loss, nausea, and fatigue. The physical reaction to an acute dose of radiation is the result of extensive cell damage over a short period of time.

Radiation therapy patients (e.g., patients undergoing cancer treatment) receive high doses of radiation over a short period of time, generally applied to a small portion of the body. Ionizing radiation is used to treat cancer because cancer cells divide rapidly and are sensitive to ionizing radiation.

It takes a large acute dose of radiation before people experience any observable physical effects. Physical effects may take days to manifest themselves and may include nausea, vomiting, and diarrhea. Other than radiation therapy patients, acute doses have only been received by survivors exposed at Hiroshima and Nagasaki and by people at a few radiation incidents at nuclear facilities.

Most radioactive material shipments contain very small amounts of radioactivity. Federal packaging regulations require that the level of radiation (measured on the external surface of shipping packages) be low enough that those who handle packages, or those who are potentially exposed to the package, will not experience any adverse health effects. When highly radioactive material is shipped, special packages are used that have been designed to withstand severe accident conditions without breaching or releasing their radioactive contents.

The probability that you, as a responder, will receive an acute dose of radiation while responding to a transportation incident is extremely low.

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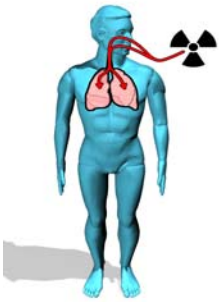
### Chronic Doses

A chronic dose of radiation is a small amount of radiation received over a long period of time. The body is better equipped to handle a chronic dose of radiation than it is an acute dose of radiation. The body can repair the damage from chronic doses, because a smaller percentage of cells will need repair at any given time. The body has enough time to replace dead or non-functioning cells with healthy ones.

Chronic doses do not result in the detectable health effects seen with acute doses. Because of cell repair, even a sophisticated blood analysis will not reveal any biological effects. Examples of chronic radiation doses include the everyday doses we receive from natural background radiation and the doses received by workers in nuclear and medical facilities.

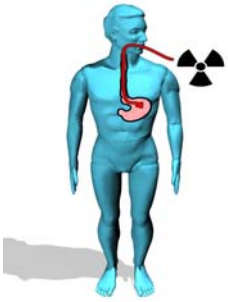
## EXPOSURE RISKS: Biological Pathways

Internal radioactive contamination results when radioactive material gets into the body. Your skin, mouth, and nose are the most obvious—and avoidable—routes to internal contamination. Radioactive material can enter the body through the same pathways as any other material.

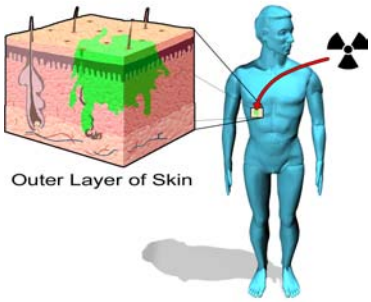


Biological pathways that can introduce internal contamination include:

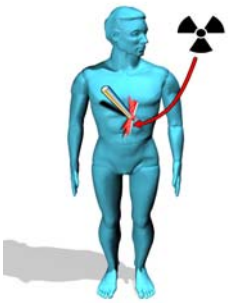
**Inhalation** - smoke particles or other airborne particulate matter may enter the body through the lungs as you breathe.



**Ingestion** - eating, drinking, smoking, or chewing contaminated items may cause internal radiological contamination.




**Absorption** - radioactive material may be absorbed through the skin or mucous membranes the same way other things are absorbed.



**Injection** – radioactive material can be introduced to the body through cuts, wounds, direct medical injections, or other punctures in the skin.

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# Check Your Understanding

1. The way radiation causes damage to any material is by _____ the atoms in that material—changing the atomic structure of the material.

2. If a sufficiently high dose of radiation is received, and a large number of cells are damaged, observable _____ may be seen.

3. A(n) _____ dose is a large dose received in a short period of time.

4. A(n) _____ dose is a small dose received in a continuous, repeated, or long-term exposure.

5. One possible health effect from a large acute exposure to ionizing radiation is:
   a) Arthritis
   b) Hair loss
   c) Rapid onset of streptococcus
   d) Increased cranial capacity

6. List the pathways by which radioactive material can enter the body:
   _____
   _____
   _____
   _____

M E R R T T




## ANSWERS

1. ionizing
2. effects
3. acute
4. chronic
5. b
6. Inhalation
   Ingestion
   Absorption
   Injection